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2DSTAT: A Machine Learning-Based System for Predicting Consumer Sentiment and Behaviour in Supermarkets

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I. Introduction

Understanding consumer behavior in supermarkets is vital for optimizing marketing, product placement, and inventory management. Retailers and manufacturers can better tailor offerings by analyzing consumer interactions [1],[2]. Traditional analytics focus on sales data, often missing the complexities of decision-making [3]. This study introduces 2DSTAT, a machine learning-based system that integrates qualitative behavior data with sales records. Using video processing and deep learning, it provides insights to help manufacturers optimize product placement, refine marketing, and enhance engagement, improving shopping experiences and boosting sales. Currently, the study focuses on 'biscuit' products due to their high demand across all age groups [4], with plans to expand to other supermarket items.

A. Aims and Objectives

The primary aim of this study is to develop a machine learning-based consumer behaviour analysis system that enhances retail decision-making. The specific objectives such as implementing machine learning model for detecting products, analyzing consumer sentiment and engagement using video-based insights, and develop a web-based dashboard for manufacturers to access analytics.

B. Significance of this Study

This research contributes to the field of retail analytics by introducing a qualitative approach to consumer behaviour analysis. By integrating video analytics with traditional sales data, the system enables manufacturers to better understand consumer preferences, optimize shelf placements, and refine marketing strategies.

II. Literature Review

Previous studies have advanced consumer behavior analysis using machine learning. A facial expression recognition model improved classification accuracy [1], while a YOLO-based sentiment detection framework effectively classified emotions [2]. IoT-based emotion tracking optimized engagement [3], and a hybrid deep learning model enhanced marketing strategies [4]. These are justifying this study's approach.

III. Methodology

A. Data Collection

Consumer interactions such as looking, touching, and picking up products were recorded in a actual supermarket with controlled setting with strategically placed cameras capturing behaviors like. For this study, we arranged for some volunteers to act naturally in front of the shelf, and their interactions were recorded using cameras. To address privacy concerns, all participants were fully informed about the study's purpose, and their consent was obtained prior to recording.

B. Machine Learning Techniques

Consumer interactions were analyzed using MediaPipe for pose estimation and deep learning models for sentiment classification. Object detection models such as YOLOv8 were trained and used to identify biscuit products. Sentiment prediction models such as FER, DeepFace and HuggingFace emotion classifier model used to assess consumer reactions and gender.

C. System Architecture

The backend developed using Express.js. The FastAPI based video processing engine processes consumer behaviour video. Data is stored in MongoDB, while an Angular-based frontend provides an interactive dashboard for manufacturers and supermarket users.

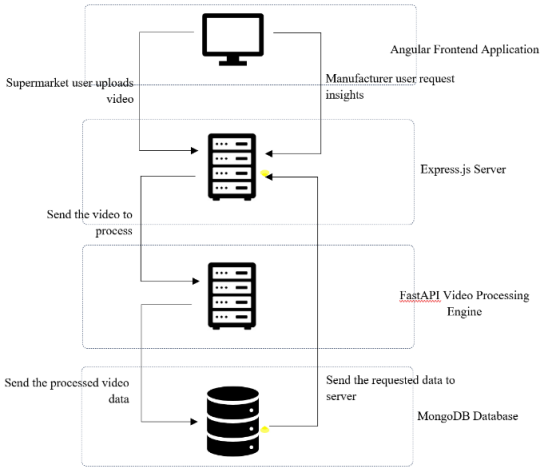

Figure 1: Flow chart of 2DSTAT

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TABLE I: CONSUMER BEHAVIOUR CLASSIFICATION ACCURACY

Consumer Actions	Accuracy
Looking at the product	90%
Touching product	80%
Picking up product	80%
Examining while holding	85%

B. *Object Detection Model Performance*

The trained object detection model showed good accuracy in detecting the products in video frames.

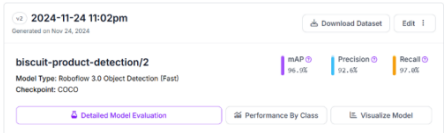

Figure 2: Object detection model accuracy

C. *Sentiment and Gender Detection Results*

The system successfully identified the sentiments and gender of the consumer while interacting with the product in different angles.

TABLE II: SENTIMENT AND GENDER DETECTION ACCURACY

Detection	Accuracy
Sentiment	95%
Gender	87%

D. *Processed Video Sample Screenshots*

Figure 3: System detects the consumer saw a trained product

Figure 4: System detects the consumer picked a product

Figure 5: The system detects the trained product

E. *Insights for Manufacturers*

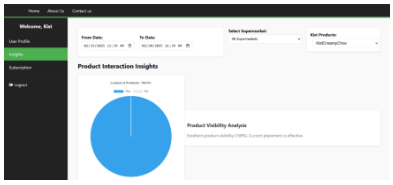

Figure 6: Pie chart for view the percentage of consumers saw their products in a particular supermarket

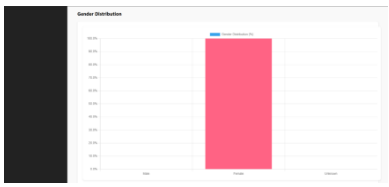

Figure 7: Bar chart for view which gender mostly interact with their product

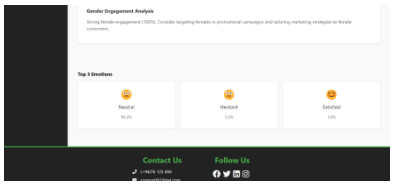

Figure 8: A Bar chart shows top 3 emotions of consumers when they interact with their product

F. *Identified Limitations*

The main limitation is the lack of real-time processing; supermarkets must upload videos manually. Future updates will integrate edge computing, real-time streaming, and AI analytics. Currently focused on 'biscuits,' the system will expand to more product categories.

G. *Ethical Considerations*

The 2DSTAT system is exclusive to supermarkets and manufacturers, with no video access for users. Captured videos are processed into JSON files and then the videos will be deleted. Supermarkets should inform their consumers about data collection, with opt-in/opt-out options, ensuring ethical and transparent data usage in retail analysis.

V. CONCLUSION

The 2DSTAT system presents a novel approach to consumer behaviour analysis by integrating video analytics and machine learning in supermarkets. The findings help the manufacturers with actionable insights beyond sales data. Future improvements should focus on optimizing real-time processing, and expanding the system to other consumer products. The study highlights the potential of machine learning-based consumer behaviour analytics in decision-making processes of retail business.

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